INITIAL REPORT

W9132T-04-C-0017

ReliOn, Inc.

Backup Power for Mission Critical Loads

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Ft. Rucker, Alabama

June 15, 2004

Executive Summary

PEM fuel cells are an ideal source of backup power to critical loads requiring extended periods of run time. Numerous military applications must remain ready and functional, even in the event of a primary power outage. To further research these requirements, this application will test the reliability of the ReliOn fuel cell systems as sources of backup power for U.S. Military Communications and Air Traffic Control and Landing Systems (ATCALS). The fuel cells will be housed in a separate outdoor enclosure. This enclosure will be entirely self-contained, providing hydrogen storage, hydrogen distribution, and a controlled environment for the fuel cell systems. The fuel cells are connected directly to the equipment's 24 or 48 Volt DC bus at each site. Once a day, AC power to the ATCALS and/or communications equipment will be disconnected, the fuel cell will start up and provide power to the load for 1 hour. After 1 hour, AC power will be restored and the fuel cells will shut down. Success will be measured by a system self-start in response to the outage and its ability to maintain a float voltage on the DC bus.

Table of Contents

Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

A demonstration of modular proton exchange membrane (PEM) fuel cells to serve as back up power for mission critical loads – ILS and other communication systems.

2.0 Name, Address and Related Company Information

Name: ReliOn, Inc.
Address: 15913 E. Euclid Ave., Spokane, Washington 99216
Phone: 509-228-6500
DUNS: 137264193
CAGE: 3K7Y7
Federal ID: 91-2191190

ReliOn is a leader in the development and marketing of modular Proton Exchange Membrane (PEM) fuel cells. The company markets a variety of commercially available fuel cells using its patented modular cartridge technology™.

3.0 Production Capability of the Manufacturer

ReliOn is located in Spokane, Washington and is a provider of commercially available PEM fuel cell systems. One thousand watt models and outdoor enclosures are available today.

All Fuel Cell systems are assembled at the Spokane, Washington facility. The current facility has the capability to produce 10 fuel cell systems per week, running one shift and without contract labor. This capacity can easily be expanded with the addition of contract labor and back shifts. If demand exceeds this capacity, the production lines could be duplicated at contract manufacturers. Three contract manufacturers could be employed in Spokane which could quadruple the capacity. Large regional contract manufacturers could also be employed if the demand existed.

Relion fuel cells are made from common materials using mature manufacturing processes in injection-molded plastic, sheet metal fabrication and printed circuit board assembly. The PEM's are purchased through a supply agreement with 3M. Minor capital expenditures are required to expand production.

4.0 Principal Investigator(s)

Name	Gerry Snow
Title	Program Manager
Company	ReliOn, Inc.
Phone	509.288.6682
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Name	Ken Hydzik, PE
Title	Strategic Account Manager
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Phone	509.288.6601
Fax	509.288.6510
Email	khydzik@relion-inc.com

5.0 Authorized Negotiator(s)

Name	Frank Ignazzitto
Title	Vice President, Sales- Government & West
Company	ReliOn, Inc.
Phone	509.288.6602
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Email	fignazzitto@relion-inc.com

6.0 Past Relevant Performance Information

- 242nd Combat Communications Squadron; Geiger Field, WA, Building 401

On March 29, 2002, ReliOn, then named Avista Labs, commissioned a 3kW, SR-72 fuel cell system with funding from the Construction Engineering Research Lab, a division of the U.S. Army Research and Development Engineering Center. The purpose of the installation was to demonstrate the viability of PEM fuel cell systems as a reliable source of power to various Department of Defense installations. Additionally, this installation would provide long-term test data of ReliOn's unique, modular PEM fuel cell system. A major project deliverable dictated the fuel cell provide over 90% availability to its specific customer loads. Specific loads powered included building lighting, building bay doors, and the building Local Area Network (LAN) switch. The system was operational for one year commencing on March 29, 2002 and maintained an uptime of 92.87%.

Company: U.S. Army Corp of Engineers, Construction Engineering Research Laboratory
Contract Number: DACA42-02-C-0002
Dollar Value: $184,300
Contact: Dr. Mike Binder
Title: Program Manager
Phone: (217) 373-7214
E-mail: m-binder@cecer.army.mil
Project Capacity: 3 kW
Date Installed: 29 March 2002

- SGS Future Installation; Cavalese, Italy

In November 2002, ReliOn, then named Avista Labs, completed the commercial sale of 13 Independence 1000 fuel cell systems to SGS Future, one of our distribution partners. Ten of these systems were installed in a parallel configuration providing 10kW of power for an installation near Cavalese, Italy. The fuel cells provide power to a mountaintop alpine lodge. Backpackers utilize the lodge, and it was desirable to employ an environmentally clean, quiet, reliable power source. The system has been installed and was operating at the end of 2002. The system was restarted in the spring of 2003. The dollar value below reflects only the cost of the fuel cells. Installation and enclosure costs were paid to a third party contractor by the customer, and not disclosed to ReliOn.

Company: SGS Future
Contract Number: N/A
Dollar Value $101,226
Contact: Dr. Andrea Tomasi
Title: Project Manager
Phone: +39 (046) 131-4489
E-mail: tomasi@itc.it
Project Capacity: 10 kW
Date Installed: 15 November 2002

- Federal Aviation Administration (FAA); McChord AFB, WA, Radio Transmit Receive (RTR) Site

On January 14, 2003, ReliOn, then named Avista Labs, installed a 3 kW fuel cell system consisting of six, Independence 500 fuel cells at McChord Air Force Base in Tacoma, WA. The formal commissioning ceremony occurred April 17th, 2003. Funding for this project was obtained from the Construction Engineering Research Lab, a division of the U.S. Army Research and Development Engineering Center. The six Independence 500's are connected in parallel to the FAA's RTR battery system. These batteries serve as a means of backup power in the event of a loss of AC power. Additionally, the fuel cells are connected to a load bank independent of the FAA's system. Six days a week, three times a day, the installation will simulate a loss of AC power and the fuel cell system will start up and provide power to the load bank for twenty minutes. Every Sunday, the installation will simulate a loss of AC power and the fuel cell system will provide power to the FAA battery bank for one hour. This installation makes clear the technical viability and cost savings of utilizing ReliOn's hydrogen-fueled PEM fuel cell systems in lieu of large lead acid battery systems. The purpose of the demonstration is to provide reliability data to both the FAA and the DoD to initiate commercial purchases of the ReliOn Independence fuel cell systems.

Company: U.S. Army Corp of Engineers, Construction Engineering Research Laboratory
Contract Number: DACA42-03-C-0001
Dollar Value: $136,342
Contact: Frank Holcomb
Title: Electrical Engineer
Phone Number: (217) 352-6511, 7412
E-mail: Franklin.H.Holcomb@erdc.usace.army.mil
Project Capacity: 3 kW
Date Commissioned: 17 April 2003

7.0 Host Facility Information

Location

Ft. Rucker, Alabama

History

In 1973 all Army Aviation flight training was consolidated to Cairns Army Air Field at Fort Rucker. United States Air Force helicopter pilots have also been trained at Ft. Rucker since 1971. Initial rotary-wing courses to advanced courses in aviation safety are taught here.

Ft. Rucker

Contact:	Mr. Eugene P. Redahan, Sr.
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Email:	RedahanE@rucker.army.mil

Contact:	Mr. Ted Waters
Organization:	1-11th AVN
Telephone:	334-225-1119
Email:	waterst@rucker.army.mil

8.0 Fuel Cell Site Information

The project at Ft. Rucker consists of four individual installation sites – localizer, glide slope, middle marker beacon and outer marker beacon (below).

Localizer

Glide Slope

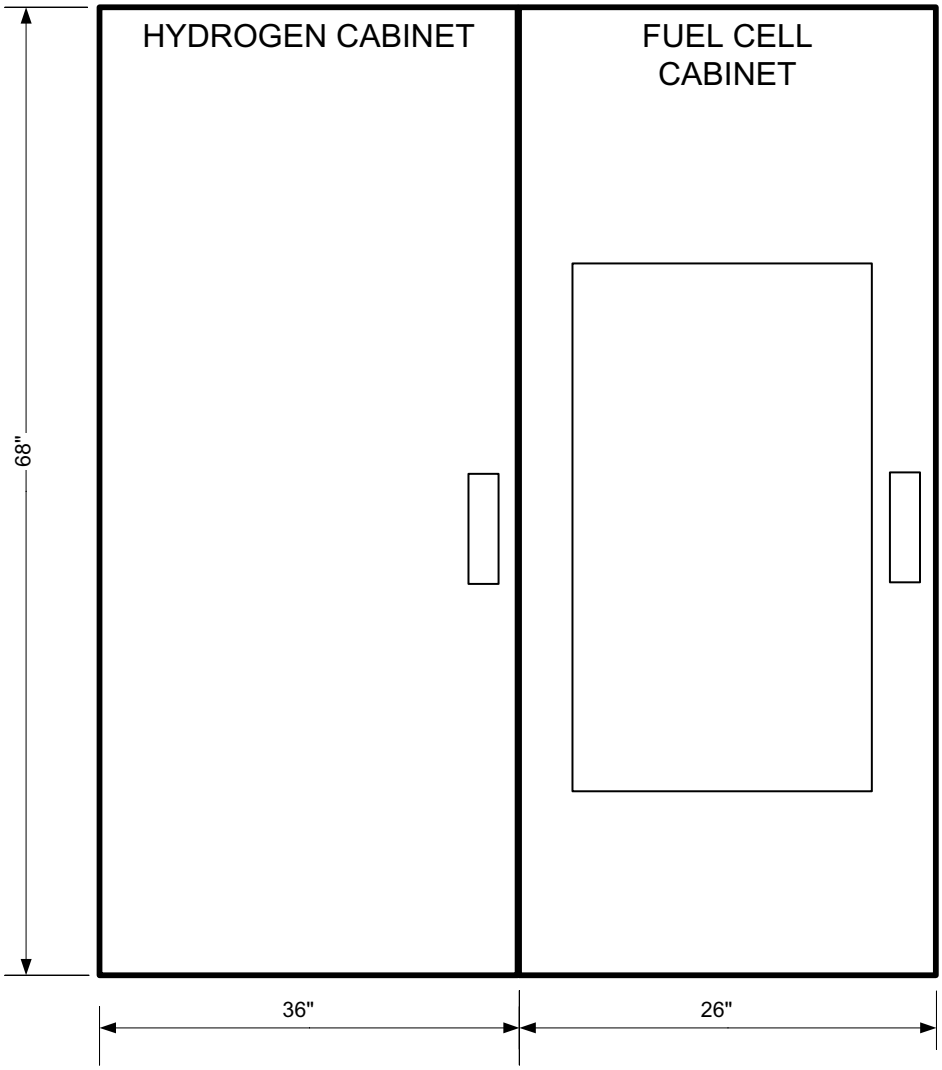
Middle Marker Beacon

Outer Marker Beacon

The localizer and glide slope are located on Cairns Army Air Field just outside of Ft. Rucker. The middle marker is located just outside of Cairns Army Air Field and the outer marker is located approximately 10 miles from Cairns Army Air Field near a peanut farm. Each site will utilize one ReliOn Independence 1000 (1kW) fuel cell system as a source of backup power.

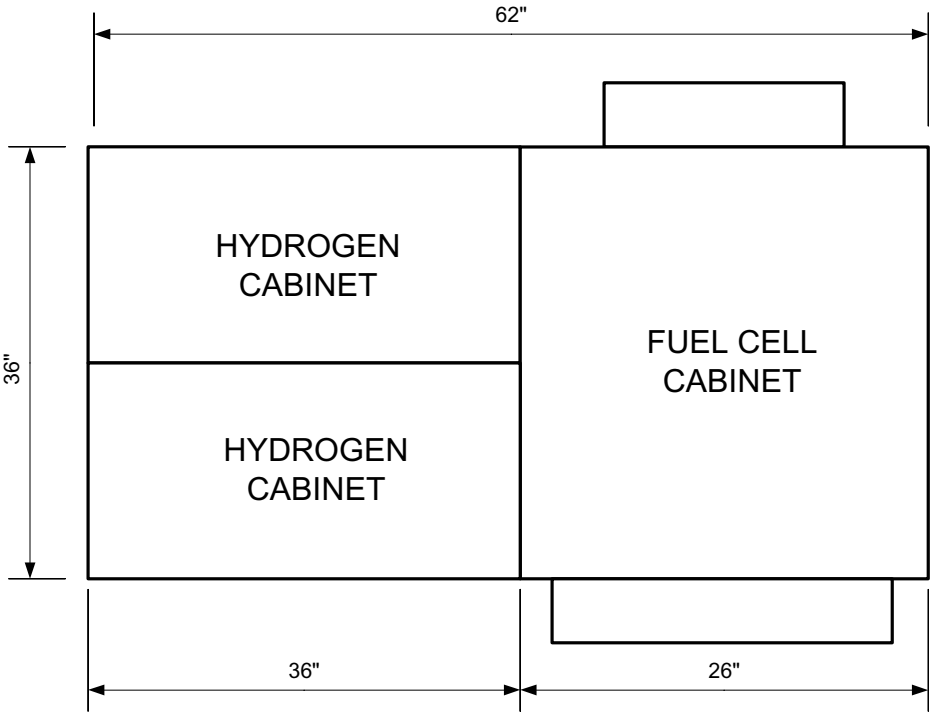
This project will test the reliability of the ReliOn backup power solution for U.S. Military Air Traffic Control and Landing Systems (ATCALS). The fuel cell systems will be connected to the DC bus at each site. The systems will be in an off, but ready state the majority of the time. The system will be designed to start up and run for one hour a day, to test the availability of the fuel cell system. Data will be collected concerning start-up times, power availability, shutdown capability, system efficiencies, load following, and the effects of varying environmental conditions. If the system fails to start up properly or provide required power to the load this will be noted in the logs as a failure and count against the 90% availability of the system.

Because ReliOn's PEM fuel cells operate at low temperatures, the system is not a cogeneration system. The system will be installed in an outdoor enclosure designed to maintain the internal temperature within the operating range of the Independence 1000.



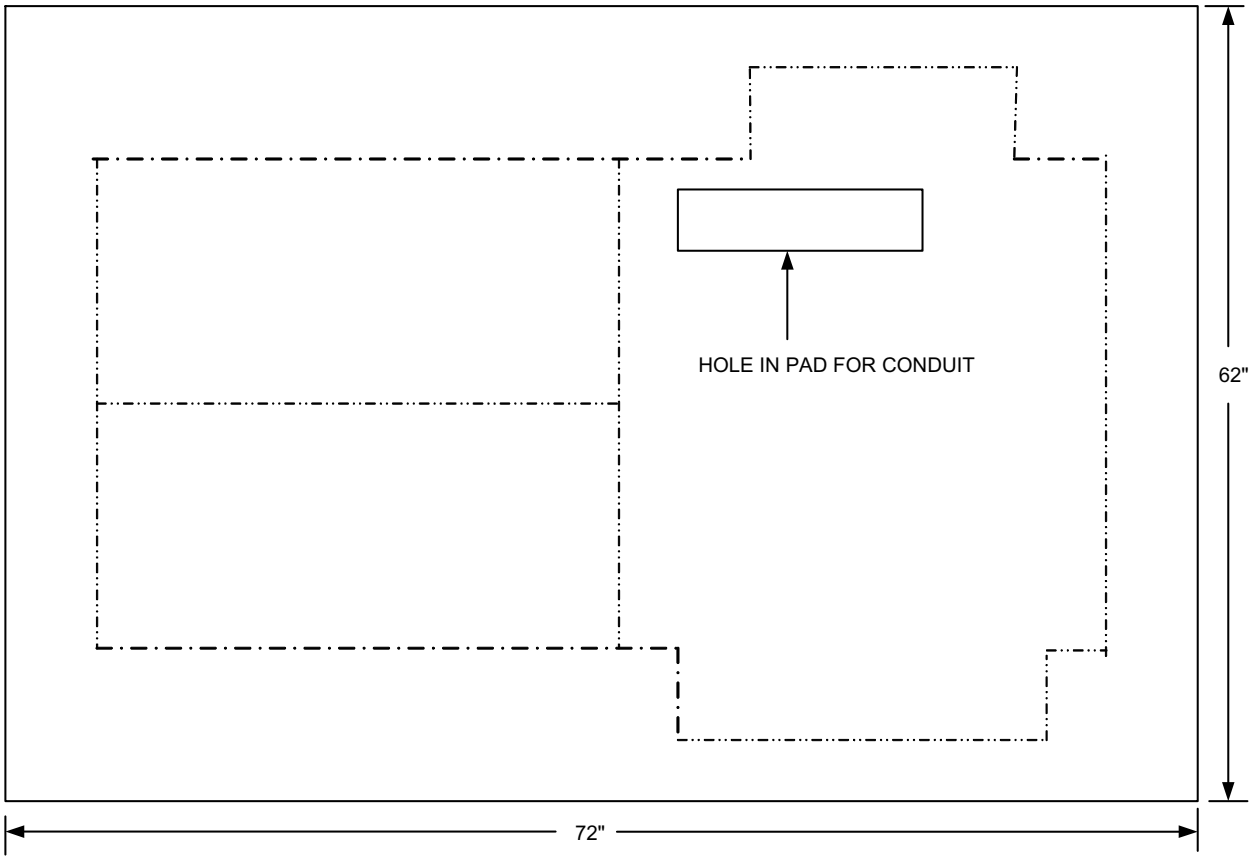
ENCLOSURE FRONT VIEW

BACK



FRONT

ENCLOSURE FOOTPRINT



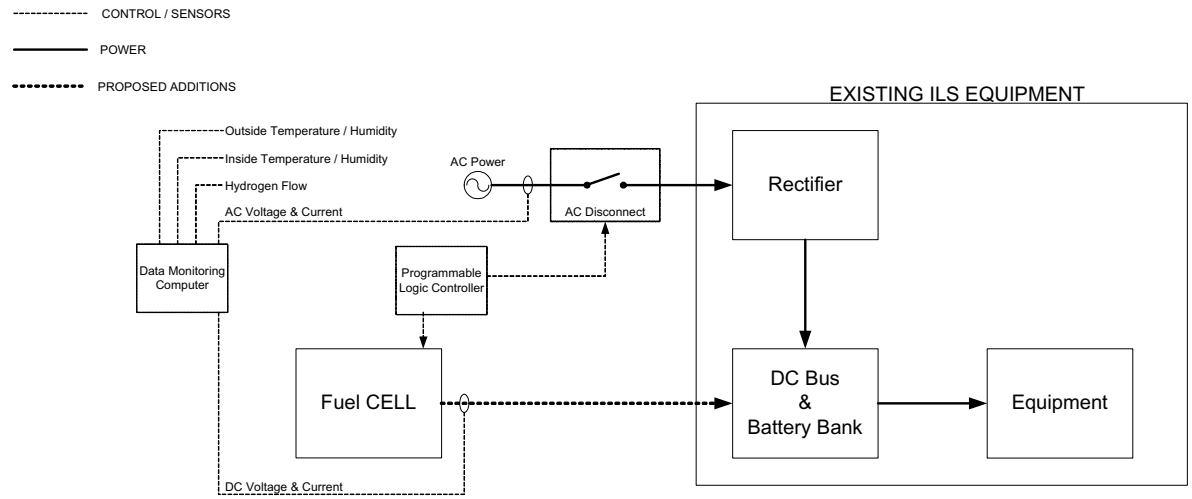
COMPOSITE CONCRETE PAD FOOTPRINT

Integrated Fuel Cell and Hydrogen Storage/Delivery System:

- 2 Hydrogen Banks
- 6 cylinders total
- Each cylinder contains 197 cu-ft of hydrogen
- Total amount of hydrogen: 1182 cu-ft
- 40kW-hours of runtime capacity
- Composite Concrete Pad

The systems will be fueled from industrial grade hydrogen gas. Compressed gas is the easiest and most commercially available source of industrial grade hydrogen. Each system will be sited outdoors in an environmentally controlled enclosure placed on a composite concrete pad. The outdoor enclosure provided by ReliOn will include a locked hydrogen storage and delivery system which ensures that the compressed hydrogen bottles are protected and accessible only to authorized personnel.
On-Site maintenance will consist of routine visual inspections and occasional equipment adjustments. The ReliOn Independence series is a system based on removable cartridges that house the PEM membranes. If a membrane fails, the system continues to operate and there is a visual indication, as well as remote indication capability with the communications system. When it is convenient, the failed cartridge can be replaced. This task can be accomplished in less than one minute without the use of tools.

9.0 Electrical System



SYSTEM FUNCTIONAL BLOCK DIAGRAM

At each of the four sites, the fuel cell systems will run in a grid-independent mode with no interconnection requirements. All systems will be in a standby/ready mode to provide backup power for critical DC equipment when there is a loss of primary AC power. The Localizer, Glide Slope, and Middle Marker will each utilize one outdoor enclosure with one 24 VDC Independence 1000. The Outer Marker will utilize one 24 VDC system for the Outer Marker ILS equipment and one 48 VDC system for the Compass Locator equipment. Electrical and communication connections between the fuel cell enclosure and each of the ATCAS shelters will be through dedicated conduit runs. All conduit runs must be buried, and the installation contractor will gain all necessary permit approvals for trenching with the base. The following connections will be established at each site:

Electrical Requirements:

- One 15 – 20 Amp circuit required at each site for AC sense, powering the data monitoring computer, and the enclosure heater. The heater is designed to keep the environment around the fuel cell above freezing to facilitate startup. Once the fuel is running, it utilizes its own heat for operation.
- AC disconnect relay between AC power and rectifier
- The fuel cell enclosure will be grounded to the existing ground cable ring at each ATCAS shelter site using 1/0 AWG bare copper ground cable. The new enclosure ground cable will be attached to the existing ground system using an approved connection compatible with local code and practice for below grade grounding.
- DC connection between fuel cell system and DC bus in customer's equipment cabinet
- All electrical work to be completed by Contract Licensed Electrician

Telephone Lines:

- One phone line required per site for data monitoring
- One pair of copper from the Localizer and Glide Slope shelters to the base central office
- Relion will provide commercial service from the base central office
- Relion will provide commercial service or wireless modem connectivity to the Middle Marker and Outer Marker shelters
- One computer with dial-up capability at each site, Provided by ReliOn

See Appendix 1 for site specific connections

10.0 Thermal Recovery System

Not applicable.

11.0 Data Acquisition System

The load at each ILS shelter is between 50 watts and 200 watts. A Programmable Logic Controller (PLC) will be used to start the fuel cell once a day for a test period of one hour. The PLC will also energize a relay at the same time to disconnect AC power from the shelter rectifier.

A data acquisition system is also included in each enclosure to monitor and record the flowing:

- Inside temperature
- Inside Humidity
- Outside Temperature
- Outside Humidity
- AC Voltage at the site
- AC current at the shelter rectifier
- DC Voltage at the shelter DC bus
- DC current from the fuel cell

All vital information from the Independence 1000 will also be monitored and recorded. The data-logging computer will be connected to the data acquisition module and fuel cell via Ethernet. The data-logging computer will be configured to dial out an alarm during any of the following conditions:

- Loss of AC Voltage
- Low DC Voltage
- Hydrogen Sensor Alarm
- Fuel Cell Major Alarm
- Hydrogen Bank Empty
- Enclosure Fan Alarm

The system will also be configured to start automatically during a loss of AC power and low voltage startup. The low voltage startup can be configured for 23, 24 and 25 VDC startup thresholds for the 24 VDC system and 46, 48 and 50 VDC for the 48 VDC system.

12.0 Economic Analysis

See Appendix II.

13.0 Kickoff Meeting Information

Completed on 27 May 2004.

14.0 Status/Timeline

On or before:

May 30:	Kickoff Meeting Finalize site layout
June 7:	Selection of contractors
June 21:	Site preparation System installation & testing
July 29:	Commissioning Ceremony Start of evaluation
July 30, 2005:	Site restoration begins

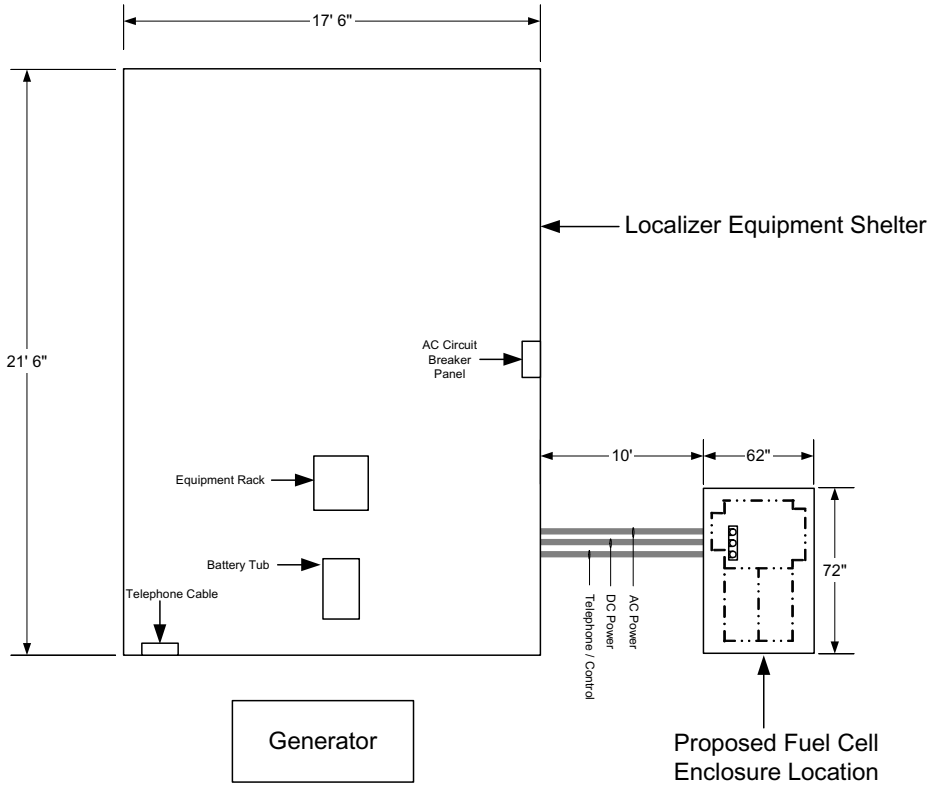
Appendix

Appendix I: Electrical connections for each of four sites
Appendix II: Economic comparison versus extended battery bridge

APPENDIX I

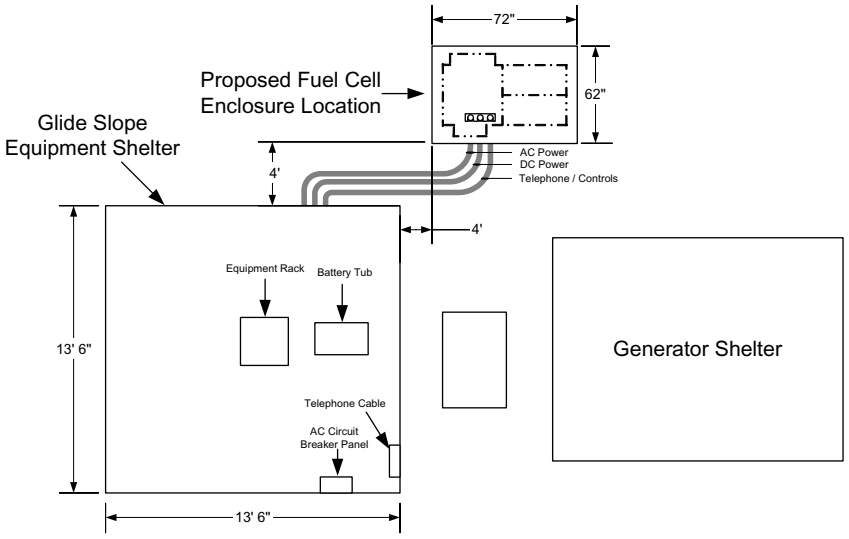
Localizer:

Load size: 50W – 200W



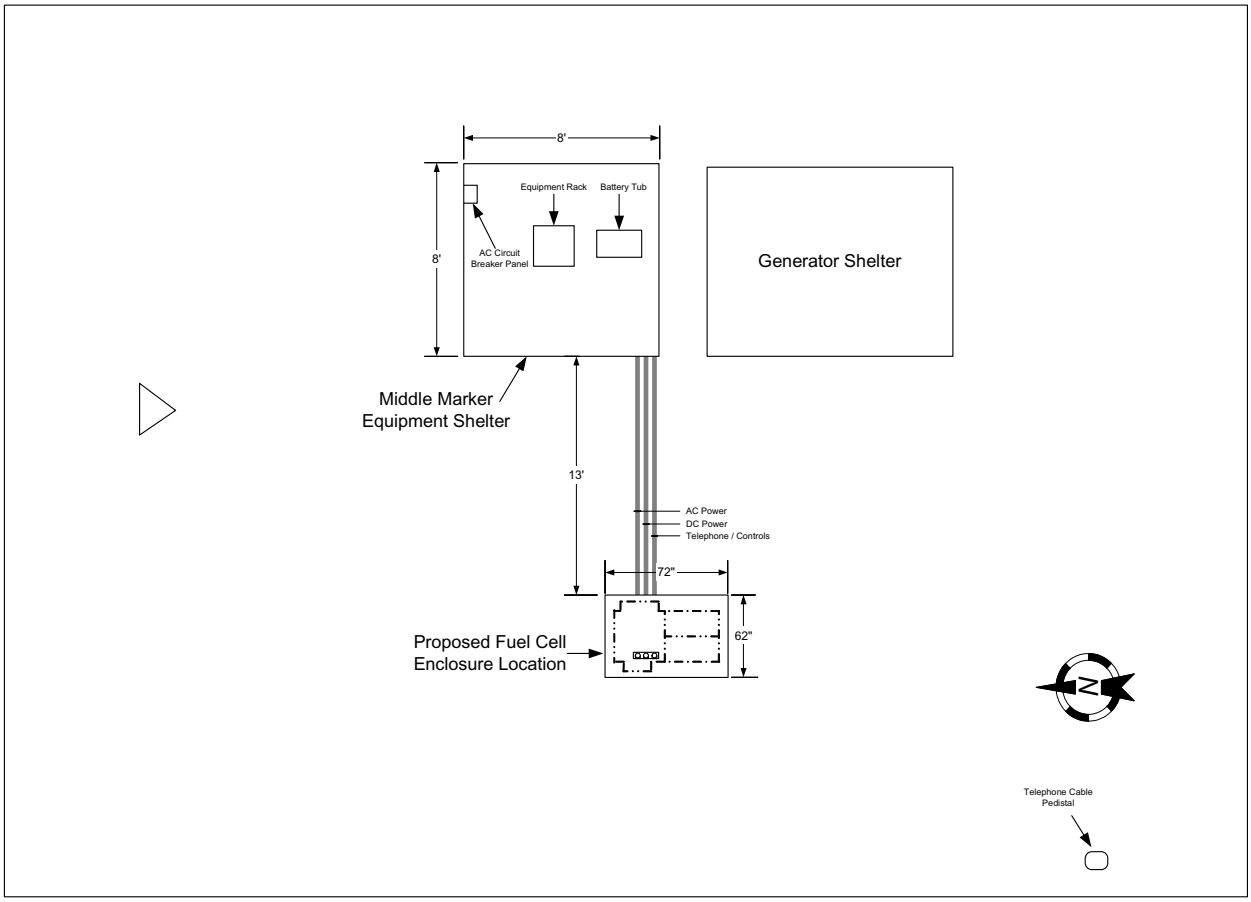
Glide Slope:

Load size: 50W – 200W



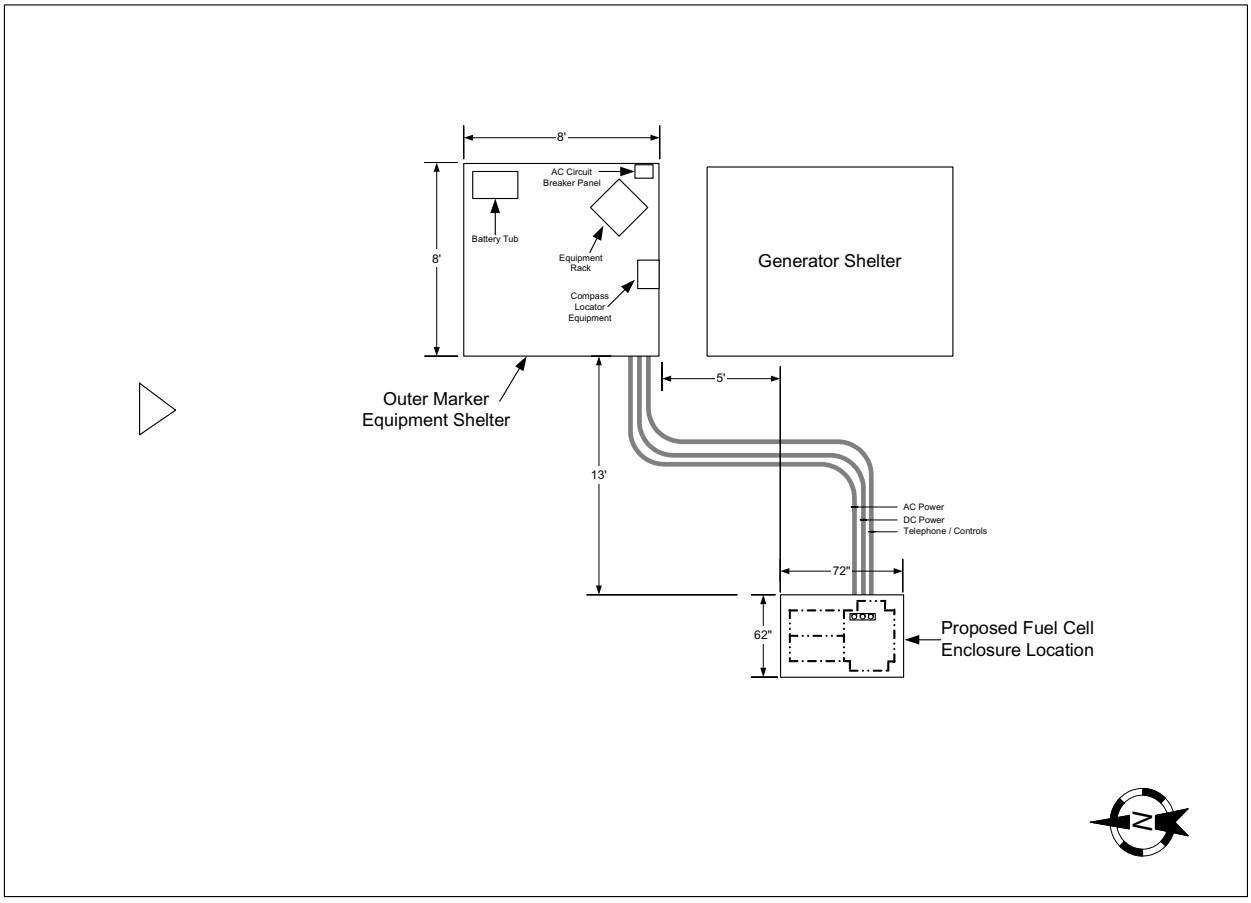
Middle Marker Beacon:

Load size: 50W – 200W



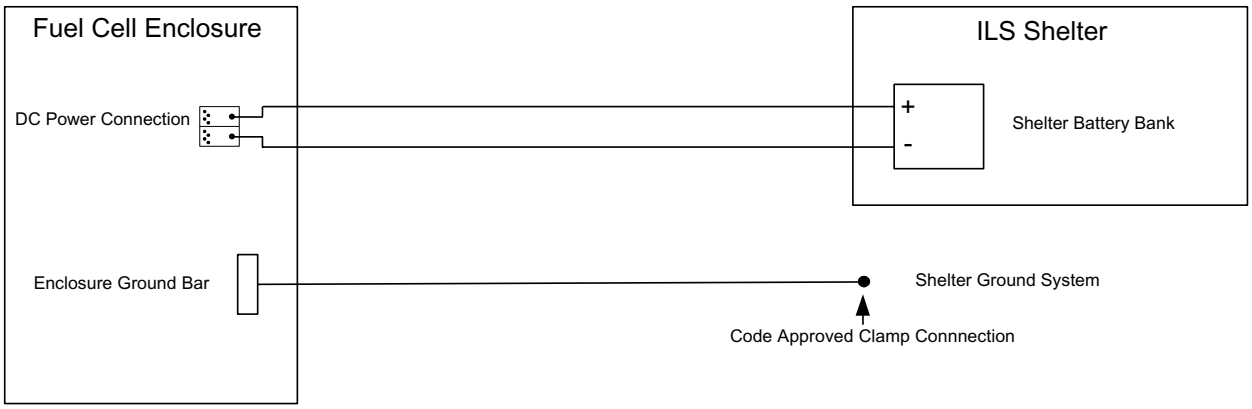
Outer Marker Beacon:

Load size: 50W – 200W

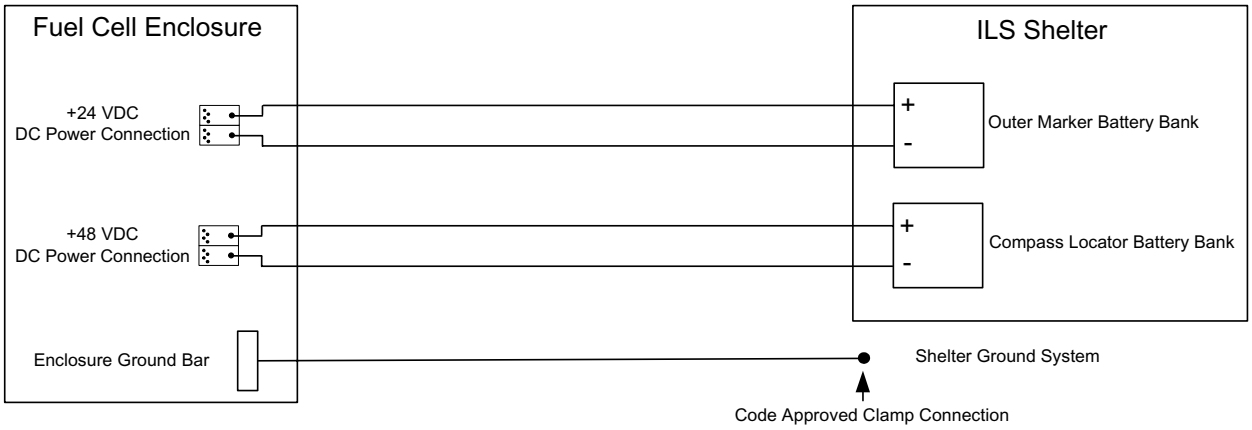


Electrical Connections:

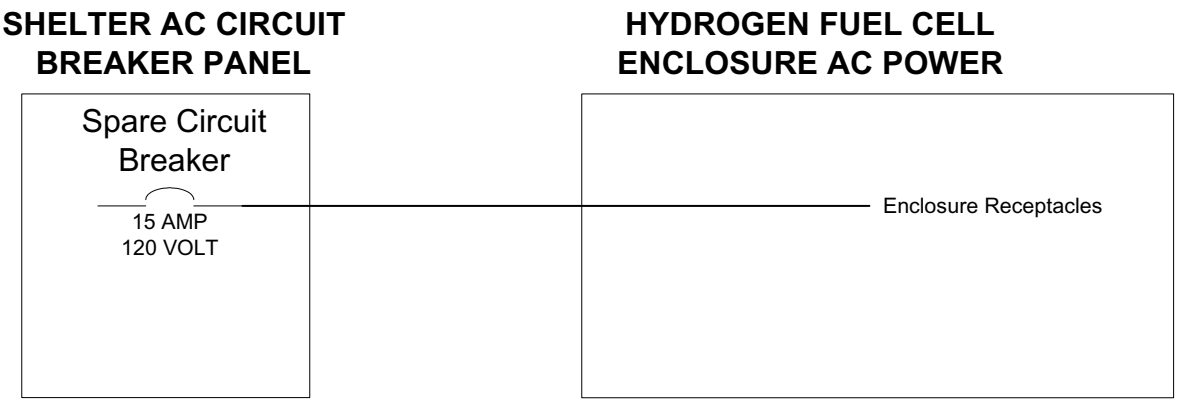
Standard DC Power Connections



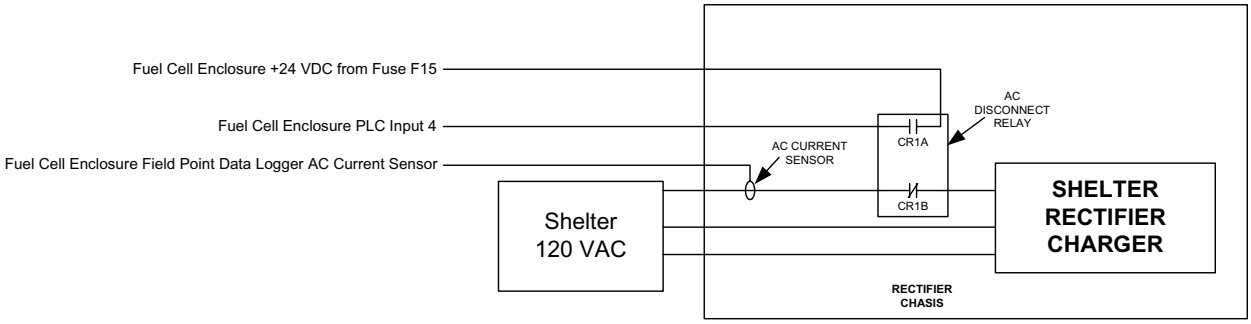
Outer Marker DC Power Connections



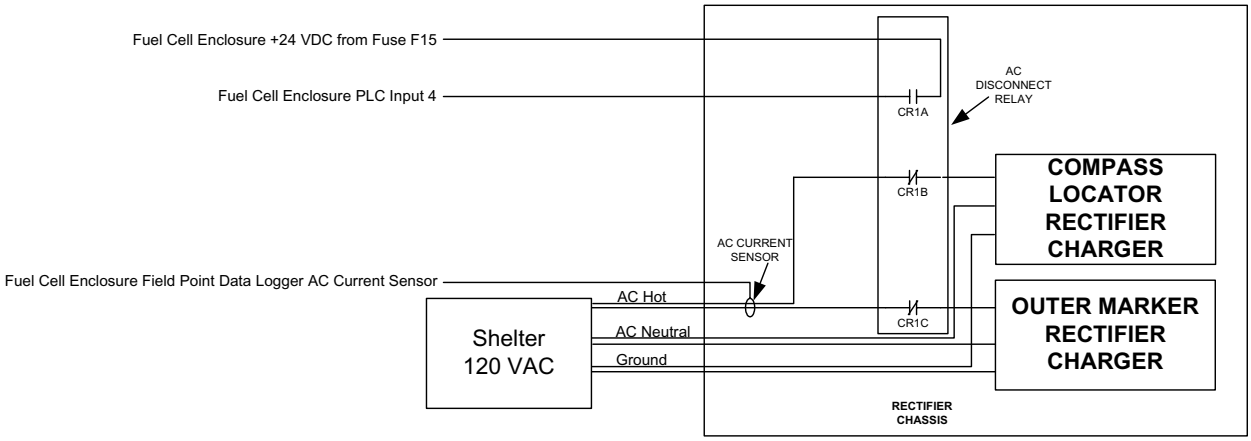
AC Power Connections



Standard Rectifier AC Power Disconnect Connections



Standard Rectifier AC Power Disconnect Connections



APPENDIX II

Economic Comparison

ReliOn Fuel Cells:

Telephone Switch (2004) - Generator with Battery String

Scenario

This analysis compares using a generator with lead acid batteries versus ReliOn modular fuel cells to back-up telephone switch equipment on military bases. Option A is a traditional approach consisting of a small string of VRLA batteries augmented by an engine generator. The engine generator is a small 5kW AC generator. Maintenance is calculated based on monthly checks on the engine generator and batteries. A monthly fuel service fee is assumed for the engine generator. The batteries in this option provide 4 hours of back up run time and are assumed to have a 5 year life.

Option B utilizes the ReliOn fuel cell solution to provide power capacity and hydrogen fuel to provide run time. Obtion B utilizes one hour of battery reserve to act as a battery bridge for startup of the fuel cell. Maintenance cost are reduced as the fuel cell can be remotely monitored and started to verify the working order of the system and check battery status. We will assume the loss of one modular cartridge every three years. Annual fuel usage is calculated assuming 4kW-hours per year.

Application Requirements:

Load (kW)	**4kW**
Run time (hrs.)	**12 hours minimum**
Discount Rate	**6%**

Option A Assumptions

Engine Generator	$	10,120	(Based on Cummins Onan GCAC-1385 Generator)
Automatic Transfer Switch	$	2,400	(Industry data)
Fuel Storage Tank and Monitor	$	1,518	(15% cost of Generator system)
Battery Stack (16kWh * 1.2 = 19.2kWh)	$	6,720	(Based on $0.35/watt-hour; 5-Year Replacement)
Installation	$	20,400	(Based on fuel spill containment, generator install, electrical tie in, and battery connection)
Fuel Service	$	650	(Based on monthly fuel cycling)
Annual Maintenance	$	3,740	(Genset = $225/mo per MA/Com, Btry = quarterly service of 4 hours @ $65/hour)

Option A Cash Flows	$	Y_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}
Capital Equipment	$	41,808					8,720					8,720
Other Initial Expenses												
Annual Expenses			4,390	4,390	4,390	4,390	4,390	4,390	4,390	4,390	4,390	4,390
Net Cash		**(41,808)**	**(4,390)**	**(4,390)**	**(4,390)**	**(4,390)**	**(13,110)**	**(4,390)**	**(4,390)**	**(4,390)**	**(4,390)**	**(13,110)**

Option A NPV **(85,504)**

Option B Assumptions

ReliOn 4 x 1kW Hydrogen Fuel Cells	$	32,200	(List price)
1 Hour Battery Bridge	$	1,680	(Based on $0.35/watt-hour; 5-Year Replacement)
ReliOn Outdoor Enclosure	$	7,500	(List price)
Replacement Cartridge	$	300	(6-Year Replacement 1x$300)
Installation	$	9,000	(Includes site prep, pad, conduit)
Annual Maintenance	$	520	(Fuel cell system and batteries, 2 visits per year @ 4hrs/visit = $520)
Annual Hydrogen Fuel	$	585	(6 Cylinders; $5/bottle/month, Fuel & Delivery)

Option B Cash Flows	Y_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}
Capital Equipment	50,965					2,200					2,200
Other Initial Expenses											
Annual Expenses		1,105	1,105	1,405	1,105	1,105	1,405	1,105	1,105	1,405	1,105
Net Cash	**(50,965)**	**(1,105)**	**(1,105)**	**(1,405)**	**(1,105)**	**(3,305)**	**(1,405)**	**(1,105)**	**(1,105)**	**(1,405)**	**(3,305)**

Option B NPV **(62,611)**

Option A NPV	**(85,504)**
Fuel Cell Advantage/Disadvantage	**22,893**

Savings = **27%**

APPENDIX III

CERL
Kickoff Meeting Notes

Fort Rucker, AL
Kick-Off Meeting Report for May 27, 2004
June 1, 2004

Project Information

Project name:	Residential PEM Demonstration Project at Fort Rucker, AL
Prepared by:	Melissa K. White
	Systems Engineer
	m-white@cecer.army.mil
	(217) 352-6511, x-7584

Distribution:	ERDC/CERL	Tom Hartranft	CF-E Branch Chief
	ERDC/CERL	Mike Binder	CF-E Project Manager
	ERDC/CERL	Frank Holcomb	CF-E
	ERDC/CERL	Nick Josefik	CF-E
	ERDC/CERL	Scott Lux	CF-E
	SAIC & ERDC/CERL	Melissa White	CF-E

Objectives

The purpose of the trip was to perform a kickoff meeting at Fort Rucker, AL, one of the FY03 Residential PEM Demonstration sites under contract with ReliOn.

Attendance

Name	Organization	Phone	**Email**
Frank Ignazzitto	ReliOn	509-981-0750	fignazzitto@relion-inc.com
Ken Hydzik	ReliOn	509-869-3580	khydzik@relion-inc.com
Melissa White	SAIC & CERL	217-352-6511 x-7584	m-white@cecer.army.mil
Frank Holcomb	ERDC/CERL	217-352-6511 x-7412	f-holcomb@cecer.army.mil
Willie Rucker	Fort Rucker	334-255-3025	Willie.rucker@rucker.army.mil
Ed Kaucirck?	Fort Rucker	334-255-1070	Edward.kaucirck@rucker.army.mil
Glen Crosby	Fort Rucker	334-255-8536	Glenn.crosby@rucker.army.mil
???	Fort Rucker	334-255-3366	
Judson Edge	Fort Rucker	334-255-9562	Judson.edge@rucker.army.mil

Avaray Johnson	Fort Rucker	334-255-1637	Avaray.johnson@rucker.army.mil

Progress Report

Accomplishments:

Decisions Made and/or Actions Taken:
Thermal welds should not be used at this site because lightning has been known to undo them.
Digging requires a lengthy permitting process, so if above ground conduit can be used, the timeline will move along much more quickly.

Supplemental Documents Attached

Photos of site

Revision Record

Number	Date and Sections	Author	Notes
1.0	June 1, 2004	Melissa K. White	Initial Version

Task Checklist

Stage	Task	Notes	Complete
Introductions	Meet all involved parties		
CERL	PEM Program Overview Presentation		
Contractor	Presentations		
Site Reps.	Any conflicts, concerns, etc.		
CERL	Question & Answer		
Site Tour	Pictures of proposed site(s).		
Site Tour	Picture of base entrance		

Meeting Agenda:
May 27, 2004
9:00 am
Air Traffic Services Command, Fort Rucker, AL

- Introductions
- Background of PEM Program – Frank Holcomb
    - Base Responsibilities
    - BAA Requirements
    - PAO
- Project Specifics – Frank Ignazzitto
    - Fuel cell basics
    - Independence 1000 specs

    - Chart on reliability
    - Sites – Glide slope, Localizer, Middle Marker, and Outer Marker
- Data Monitoring, Site Requirements
    - Fuel Cell will start up in about 30 seconds to meet the load requirement of 40-200 W
    - Simulated outages will take place once per day for one hour
    - In case of real outage, back up generators will operate as usual. Fuel cell will not run at the same time and will not overcharge batteries
    - Questions about lightning & storm protection
    - Questions about hydrogen storage and safety (6 cylinders @ 197 ft^3 can run 7 days at 200 W, possibly up to 6 months @ 1 hour/day)
    - Question about connectivity at outer marker. Frank Ignazzitto said he found a telephone line he could use there.
    - Question about house near outer marker, should not be concerned about hydrogen out there.
    - Using industrial grade hydrogen
    - Each of the four sites has one Independence 1000, except the outer marker, which has two. One of the outer marker FCs runs at 24V, while the other runs at 48V. These two voltage settings can not currently be provided from one Independence 1000.